Method of increasing the fire resistance of wood

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Abstract. The use of impregnation based on soda ash and boric acid as one of the ways to increase the fire resistance of wood is considered. The method of testing the initial impregnation on three types of wood is described. The result of the tests was a justification for the use of this impregnation to increase the fire resistance of wood.

1. Introduction

Fire resistance of wood is achieved with the help of flame retardants and antiseptics[1-3]. The action of the former is to protect the material from direct contact with fire or by limiting the oxygen supply to it, thus preventing it from catching fire. The latter make the wood more resistant to the effects of various types of microorganisms and insects.

2. A review of the literature

Ensuring fire safety of buildings and structures containing materials made of wood is achieved by processing with various flame retardants. [4,5,6].

For these purposes, the most often used aqueous solutions of borax, potash, ammonium phosphate, sodium acetate etc.

Currently, scientists continue to search for flame retardants and antiseptics, relatively cheap and environmentally friendly. In connection with the provision of fire protection, the problem of wood remains relevant. [7,8]. For it is necessary how to determine the substances (or), their depth and distribution by [9].

3. Materials and methods

To increase the fire resistance of wood, it is proposed to use an impregnation from a mixture of soda ash and boric acid on a water basis, consisting of a liter of water, 0.11 kg of a mixture of soda ash and boric acid in a ratio of 3:1.

For the production of soda ash, "food" soda (sodium bicarbonate $NaHCO_3$) is used and calcined at a temperature of 200^oC until the release of water vapor and carbon dioxide CO_2 is stopped. Soda ash is used as a flame retardant, limiting oxygen access to the wood as much as possible, and eliminating the occurrence of fire in a wooden structure. Boric acid is an antiseptic and makes wood biostable.

For conducting the experiment, prepared samples from birch, beech and pine. 40*40*40 mm, are subjected to impregnation with the prepared mixture according to the following scheme:

to form the 1st layer of impregnation, the samples are placed in the solution for 40 minutes, followed by drying for 4 hours. The 2nd and 3rd layers are prepared in the same way. Before and after impregnation, the color of the samples remains constant.

Then, the samples are weighed, and the data is entered in tables 1-3.

For fire resistance testing, a universal unit for determining the group of hard-to-burn materials and fire-resistant properties of coatings and impregnating compounds for wood processing "Ceramic tube" is used [10].

The tests are performed in the following order:

- the sample is placed in the clamping device and brought to the gas burner;
- the gas burner is switched on;
- after the sample is ignited, the gas burner switches off.

Similar actions are performed for all wood samples.

4. The results of the tests

The initial mass of the samples and the values obtained during the tests for each sample (mass after three penetrations and mass after testing of each sample, as well as the time of charring, smouldering and burning in minutes) are presented in tables 1,2,3.

Table 1. Main features indicators beech tree.

Type of blank	Sample number	Sample initial mass(g)	Weight after impregnation(g)	Weight after test(g)	Charring (min)	Smouldering (min)	Burning (min)
Beech	1-1	46.800	49.592	40.300	0:30	0:40	1:20
	1-2	45.969	49.842	43.600	0:40	1:45	2:00
	1-3	45.563	49.409	43.890	0:20	0:30	1:06
	1-4	45.146	49.949	40.510	1:46	1:58	4:53
	1-5	45.235	49.031	40.430	1:10	1:47	3:20
	1-6	45.532	49.329	43.740	0:30	0:45	1:18
	1-7	46.800	50.630	47.800	0:20	0:35	3:05
	1-8	45.046	49.736	45.120	0:45	1:05	2:20
	1-9	46.570	50.391	45.390	0:25	0:35	1:33
Average value		45.851	49.767	43.422	0:25	1:04	2:19

Table 2. Basic indicators of birch trees.

Type of blank	Sample number	Sample initial mass(g)	Weight after impregnation(g)	Weight after test(g)	Charring (min)	Smouldering (min)	Burning (min)
Birch	2-1	36.054	42.680	30.230	0:30	0:35	1:40
	2-2	34.537	40.690	31.610	0:23	0:45	1:03
	2-3	34.700	40.095	30.900	0:24	0:35	2:56
	2-4	34.710	40.903	27.210	0:15	0:17	0:23
	2-5	33.909	39.799	30.400	0:15	1:10	1:10
	2-6	35.071	41.367	35.700	0:25	0:32	1:13
	2-7	33.778	39.650	23.300	0:15	0:20	1:00
	2-8	35.488	41.281	34.280	0:15	0:18	0:20
	2-9	35.235	41.330	35.400	0:17	0:23	1:03
Average value		34.831	40.866	31.003	0:20	0:33	1:00

Table 3. Basic indicators of pine trees.

Type of blank	Sample number	Sample initial mass(g)	Weight after impregnation(g)	Weight after test(g)	Charring (min)	Smouldering (min)	Burning (min)
Pine	3-1	26.935	32.836	23.360	1:30	6:00	8:18
	3-2	28.410	34.129	26.580	2:35	19:00	It didn't catch fire
	3-3	30.353	36.684	25.140	2:30	4:05	7:20
	3-4	28.168	34.321	30.080	3:00	13:00	23:00
	3-5	28.032	34.127	30.690	1:00	5:00	13:40
	3-6	28.026	34.993	30.020	1:00	2:00	15:30
	3-7	28.362	34.056	30.450	0:50	1:00	1:10
	3-8	31.831	37.044	30.780	0:40	1:20	2:20
	3-9	29.093	35.361	25.300	1:50	2:00	3:50
Average value		28.821	34.839	28.044	2:02	6:32	8:30

Also, the indicators obtained during the tests for each sample of beech, birch and pine are presented graphically (Figures 1, 2, 3).

The arithmetic mean value of mass loss of 9 beech samples was 12.7 %, which corresponds to the 2nd group of fire-resistant efficiency of the tested fire-resistant coating with this method of its application (Figure 1).

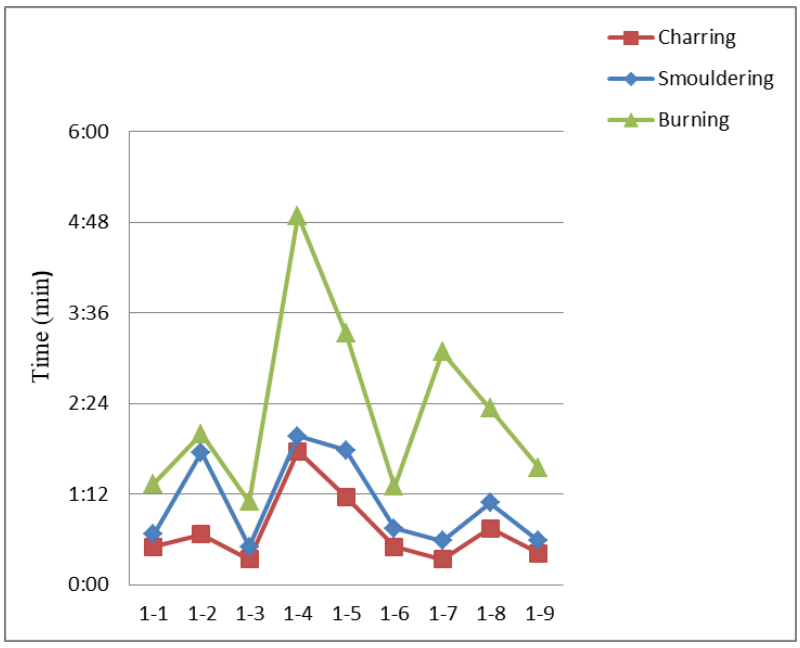

Figure 1. The time of smouldering, burning and charring of beech samples.

The arithmetic mean value of mass loss of 9 birch samples was 24.1 %, which corresponds to the 2nd group of fire-resistant efficiency of the tested fire-resistant coating with this method of its application (Figure 2).

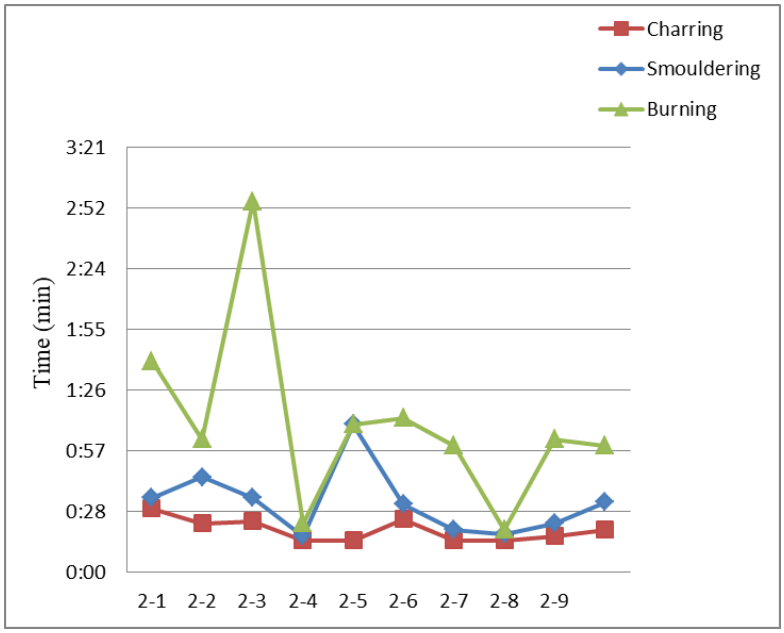

Figure 2. The time of smouldering, burning and charring of birch samples.

The arithmetic mean value of mass loss of 9 pine samples was 19.4 %, which corresponds to the 2nd group of fire-resistant efficiency of the tested fire-resistant coating with this method of its application (Figure 3).

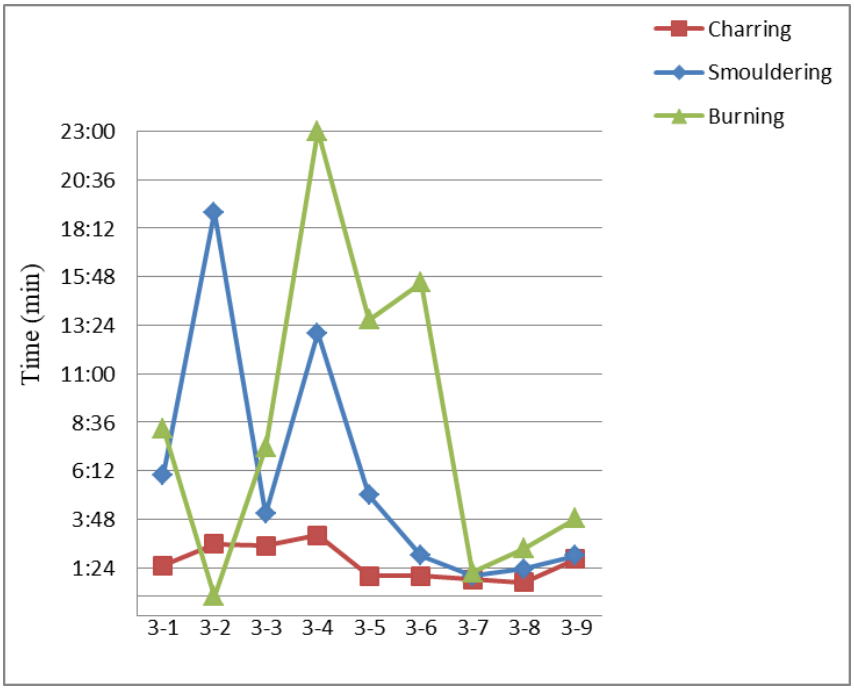

Figure 3. The time of smouldering, burning and charring of pine samples.

5. Conclusion

For all the tested samples of wood species, a group of fire-resistant effectiveness of fire-resistant coating was established for this method of applying it. Water-based impregnation with soda ash and boric acid was most effective on beech samples. Achieving the proper quality of wood impregnation is

impossible without appropriate control of the moisture content of samples, the depth of impregnation, the quality of preparation of antiseptics or flame retardants. To do this, it is necessary to clearly determine the amount of absorbed substance (antiseptic or flame retardant), the depth of their penetration and the uniformity of distribution on the wood**.**

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